Testing and calibration

The easiest way to check the operation of the circuit is to mount a temporary potentiometer of between 500Ω and 5kΩ between terminals 3 and 7 of the connection strip at the rear of the unit, with the rotor grounded to pin 1.

Switch on the control box and rotate the potentiometer to one end of its travel. Adjust RV1 on the logic board until the most southerly led is illuminated and the one next to it is just extinguished. Rotating the temporary potentiometer will cause the leds to illuminate sucessively until south is reached again, which should be at the end of its travel. If this is not so, leave the temporary potentiometer at the end of its travel and again adjust RV1 until the most southerly led is illuminated, as described above. The unit should now work correctly.

Problems

Capacitor C1 on the logic board was introduced to bypass induced ac voltage on the control wires when the motor is running, which causes more than one led to be illuminated at a time. If this problem arises try reversing the wires to RV1 or increase the smoothing capacitor in the indicator power supply.

The value of R5 determines the changeover point from IC1 to IC2. If the transition is not smooth, try changing the value of this resistor. A temporary 10kΩ potentiometer can be inserted in its place and adjusted for a smooth changeover between leds 15 and 18 (due north). A fixed resistor should then be inserted after measuring the resistance of the potentiometer.

Conclusion

In use there is no difference between this display and the meter it replaces as far as controls and calibration are concerned. However, the ease by which a beam can be set makes one wonder how one managed without the display before. The cost is minimal, all parts are readily obtainable, and one will be well rewarded for the couple of evenings' work it takes to construct the display. □

Third overtone ladder crystal filters

by J. A. HARDCASTLE, G3JIR*

Introduction

Crystal filters, both ladder and lattice, are usually designed to operate at the fundamental frequency of the constituent crystals, which tends to limit the operating frequency to the range below 20MHz. However, it was recently suggested to the author by Akira Kobayashi, JA1JIX, that the overtone modes might also be used, enabling even higher frequency filters to be constructed. To support his suggestion he enclosed a quantity of 34·16MHz miniature crystals which were used to obtain the following results.

Crystal measurements

Before attempting to make a ladder filter it was considered to be desirable to check the frequency difference between the series and parallel resonance at the third overtone. If this is less than 3–4kHz, approximately, it is unlikely to be possible to make a filter with a 2·4kHz, −3dB bandwidth.

The crystal test circuit is shown in Fig 1. Fortunately a sufficiently high frequency signal generator was available, but the 34·16MHz filter output had to be converted to 4·16MHz to allow an hf wave analyser to be used as a calibrated detector.

The crystal's series resonant frequency may be found by tuning the signal generator for maximum output, and the parallel resonant frequency, which is slightly higher, is indicated by a sharp dip in output. However, the series resonance peak is relatively broad and a more precise indication can be obtained by comparing the phase of the signals at the input and output. This is done by connecting two test probes from a double-beam oscilloscope to either side of the crystal. It is now possible to tune for the frequency at which the two signals are in-phase, which is the series resonant frequency. Using this test method the resonance is well defined and the measurements are readily repeatable.

Typical results of these measurements are:

Fundamental mode:

f_s 11,383·5kHz; f_p 11,404kHz; $f_p - f_s$ 20·6kHz.

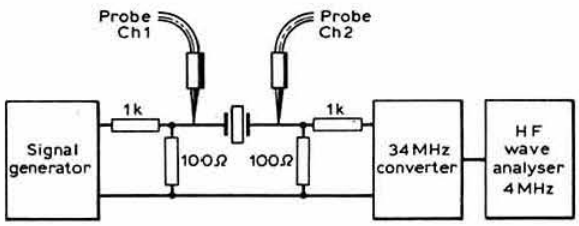

Fig 1. Crystal test circuit. High impedance (1MΩ) oscilloscope probes are used to measure the phase difference between input and output

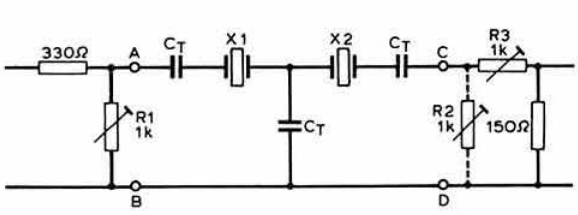

Fig 2. Two-crystal test circuit. The variable resistors are set to the required terminating impedance while measuring across A–B and C–D with an ohmmeter. For impedances below 100Ω R3 is replaced by 100Ω fixed resistor and R2 is fitted. R2 is omitted above 100Ω

*82 Acacia Avenue, Huyton, Liverpool L36 5TP.

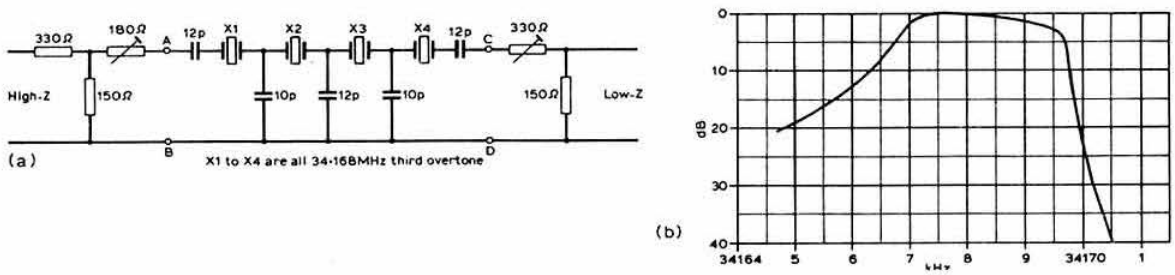

Fig 3. Four-crystal filter: (a) circuit, (b) frequency response. The input and output impedances are 330Ω

Third overtone:

f_s 34,166·3kHz; f_p 34,171·5kHz; $f_p - f_s$ 5·2kHz.

It should be noted that the frequency spacing of the series and parallel resonance is much less at the third overtone than at the fundamental, although it is still adequate for ssb reception.

Preliminary measurements

Using the two-crystal test circuit, Fig 2, the −3dB bandwidth, measured for several impedances, is as follows:

C (pF)	R(Ω)	−3dB bandwidth (Hz)
33	86	1,442
22	130	1,747
10	285	2,184

The desired 2·4kHz, −3dB bandwidth cannot be obtained using any practicable impedance, but the −6dB bandwidth is 2,988Hz in the last test, so it was decided to proceed with the tests on the assumption that the smallest capacitor in each filter would be 10pF.

Six-crystal filter

The circuit and frequency response of a six-crystal filter are shown in Fig 4. The passband ripple is much greater than the desired 1dB and could not be reduced below 2·3dB, even after trimming both input and output series capacitors. Initially this was thought to be due to the spread of the series resonant frequency of the individual crystals, and a further batch of crystals was loaned by JA1JIX so that six carefully matched crystals could be selected, but no improvement could be obtained. It was therefore concluded that the excessive ripple is due to the stray capacitance having an overriding influence, because of the relatively high frequency and impedance at which the filter is operating. Possibly further improvements could be made by trimming the other capacitors while observing the response on a wobbulator.

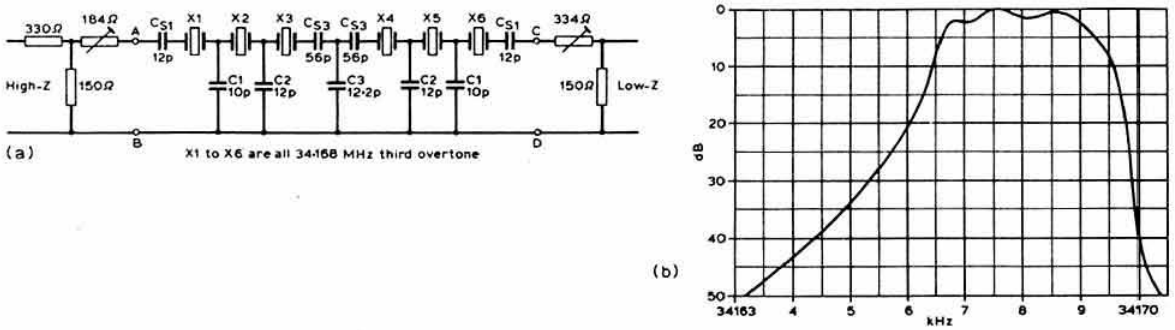

Fig 4. Six-crystal filter. The insertion loss in the passband, measured between A-B and C-D is 2dB. Input and output impedances are 334Ω

Four-crystal filter

A rapid assessment of the feasibility of making a 34MHz filter may be made by testing the four-crystal filter shown in Fig 3(a).

If C1 is made 10pF, then $R = \frac{0{\cdot}712 \times 10^6}{2\pi \times 34{\cdot}168 \times 10}$

$= 332\Omega$

and $C2 = \frac{0{\cdot}827 \times 10^6}{2\pi \times 34{\cdot}168 \times 332}$

$= 11{\cdot}6$ pF

The frequency response is shown in Fig 3(b). The −3dB bandwidth is 2,650Hz, and the passband displays a smooth curve with negligible ripple. As expected for a lower-order filter, the lf band edge has a poor rate of cut-off. However, the results are sufficient confirmation that the usual design procedure is applicable to crystals used on their third overtone.

Conclusion

As shown in the frequency response curves, the rate of stopband cut-off of these filters is relatively slow, which precludes their direct use as ssb filters, but their performance is sufficiently good for use as "roofing filters" in up-converters; further selectivity being achieved by lower frequency filters in subsequent stages.

These tests have been confined to the third overtone because of lack of vhf test equipment, but it seems probable that at least the fifth overtone could also be used.

Finally, the author is greatly indebted to Akira Kobayashi, JA1JIX, for suggesting these tests and for providing the materials for carrying them out. □